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16. ABSTRACT

A procedure for determining acceptable areas of non-compliance (mixing zones) around point source discharges is described that is based on the assignment of relative ecological values to different areas using environmental maps.

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USES OF ENVIRONMENTAL MAPS IN DETERMINING AREAS OF NONCOMPLIANCE

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INTRODUCTION

Regulatory mechanisms are required to protect the balanced communities within the Great Lakes by limiting the total areas of potential degradation. One mechanism is the area of noncompliance (or mixing zone) which is defined as that in the vicinity of a discharge where water quality objectives may not be met.

In order to assess the overall impact of discharges, one must be able to evaluate the total effect of all areas of noncompliance. The basic question to be answered is: What level of potential damage is acceptable? The answer to this requires knowledge of the total biological value in the water body segment as well as an assessment of the risk associated with sacrificing a portion of this total value. Thus, how much of the total biological value can be affected by areas of noncompliance without adversely influencing balanced communities within the segment?

Several principles apply to most areas of noncompliance. A most important principle is that areas of noncompliance are areas where water quality objectives may not be met and damage may occur; therefore, the permissible size of all areas of noncompliance within a water body is dependent on the acceptable amount of damage. Since perfect conditions must be considered, I'm sure there are portions of the Great Lakes where unacceptable damage is already widespread. For obvious regulatory reasons, the dimensions of a single area of noncompliance should be specified so that both the discharger and the regulatory agency know its bounds. While there are principles about the size and shape that can aid in decision-making, an area of noncompliance should be determined by taking into consideration the unique physical and biological features of the receiving water. In addition, limits must be placed on the water quality permissible within mixing zones.

Although the conditions of noncompliance should be determined for each site, there are some general principles. Conditions that are rapidly lethal to locally important and desirable aquatic life should not be permitted. Generally, rapid mixing is desirable. Many planktonic organisms are such weak swimmers that they must drift through the area of noncompliance and will be exposed to its conditions for a long period of time, particularly in lakes. Therefore, toxicity or adverse conditions should allow these organisms to survive without undue damage or stress. In addition, concentrations of adverse pollutants which attract animals are more troublesome than those avoided by aquatic life. For example, crowding together in a heated plume may enhance disease susceptibility and transmission.

BIOLOGICAL CONSIDERATIONS

From a biological standpoint, the location of the area of noncompliance is important. It is generally true that an offshore discharge has a lesser potential for adverse effect than a comparable onshore discharge into shallow water. Shallow water generally has a higher biological value and is more productive, since food production is greater in the shallow water zone. Light penetration is sufficiently deep to support growth of periphyton, attached algae, and rooted vegetation; terrestrial food organisms and nutrients from runoff are commonly more plentiful; there is a greater variety of substrates (sand, sediment, and rubble as contrasted to mostly fine sediment in deeper water) that provide habitat for many kinds of food organisms; and oxygen concentrations are more favorable because wave action and diffusion processes transport oxygen to the bottom. The number and variety of fish are greater in shallow areas because they are used as spawning and nursery grounds. In addition, prior to spawning migrations into tributary streams, numerous fish species concentrate in shallow waters until conditions are optimal for spawning runs. The reasons for this are numerous: cover provides more protection from larger predators; the more diverse substrates support a greater variety of species in larger numbers than the more uniform habitat of deep waters; and many fish species migrate through the shallow shore zones. Protected bays and coves are often the most biologically important, probably for the above reasons, but also because wind and wave action are potentially less damaging during storms.

In some instances, however, the very shallow water (less than a few meters) can be less productive because of wave action by wind or shipping activities can produce an unstable substrate of shifting sand and sediment. Areas of noncompliance in shallow water affect a greater benthic area due to limited dilution volume and natural turbulence resulting in top to bottom mixing. Areas of noncompliance should not be positioned so as to block the migratory routes of important species. Another consideration in recreational uses, such as water contact sports and sport fishing which are concentrated in the shore zone. This zone is also important to the aesthetic appeal of water bodies.

The foregoing discussion identified certain biotic zones related to water depth (e.g. shore zone) that are more important than others. Depth then can be used initially as a simple and convenient tool to delineate the various zones on environmental maps. The light intensity at which oxygen production in photosynthesis and oxygen consumption by respiration of the plants concerned are equal is known as the compensation point, and the depth at which the compensation point occurs is called the compensation depth. This depth will vary of course in any segment and is dependent upon season, time of day, cloudiness of the sky, condition of the water (turbidity), and other factors. An approximate determination of the compensation depth as the means of differentiating the shallow and deep water zones is simpler than conducting

a thorough biological characterization necessary for adequate environmental maps. If such a characterization, based on the various biological populations, is available in adequate detail, it should be used.

BIOLOGICAL VALUE

As noted above, the various biotic zones existing within a portion of a water body must be appropriately defined in environmental maps together with additional data on socio-economic, aesthetic, and commercial considerations. As well, these biotic zones have different biological values. Common sense indicates that areas of noncompliance should be located in the less valuable biotic zones or in those with larger areas. Thus, a biological value for the various biotic zones could be established in order to allocate areas of noncompliance. Zones of high importance would be assigned high biological value.

Although the biological or environmental value determination cannot be strictly objective, the expert opinion of biologists familiar with the local situation must be utilized. Highly valued trout waters, areas inhabited by endangered species, and many very productive areas might be considered invaluable and given a value of infinity and thus excluded from consideration as discharge areas. Value can be based proportionately on the ratio of the species diversity in the areas. Current-swept mid-channels of connecting waterways or deep waters, devoid of dissolved oxygen (D.O.) can both be given low value. When a competent data base for establishing biological value does not exist, one may assume the biological value to be the same for all biotic areas (i.e. the value of a unit area is inversely proportional to the total area in each zone). Thus by proportionately restricting the area of noncompliance to the same percent area used for mixing, one avoids placing all areas of noncompliance in one biotic zone. As is shown later, the biological value is important because it defines the upper limits on the area of each biotic zone to be used for mixing. The limits allow dischargers to select better sites and permits regulatory agencies to encourage discharges into the areas least likely to be damaged. The concept of assigning biological value is also important because the total area allocated to noncompliance can be more easily and accurately allocated than areas for individual point sources. This is because any error is distributed proportionally to each area and the decision considers the potential combined effects of all discharges. To be done by competent staff, this only needs to be decided once.

LEVEL OF PROTECTION

What percentage of total biological value should be used? Conditions necessary for all life history processes may not be provided for in areas of noncompliance. When an excessively large percent of a water body segment is made up of these areas, the population of some species will decline and an unpredictable chain of events may ensue. Furthermore, conservative estimates

of an acceptable percentage of an aquatic environment to be allocated to areas of noncompliance must be made since predictive capabilities are uncertain. Determination of the amount of a segment's biological value to be allocated is based on a variety of criteria including: type of waterbody, water velocity, depth, number and type of habitats, migration patterns, nature of the local food chain, and present extent of degradation. Level of productivity, water temperature, ability of tributary waters to provide recruitment, value to humans (aesthetic, commercial and sport fishing, recreational), endangered species, and other factors should also be considered.

It is acknowledged that any estimate of the amount of area assigned to noncompliance must be based on expert opinion. However, acceptable risk differs between waterbody segments since there are varying degrees of protection desired or required for different waterbodies. Several degrees of protection are recommended: Maximum level of protection for fragile environments; low level of protection for the less valuable environment or an environment most capable of withstanding insults; and a moderate level of protection intermediate between the two. The percentage of biological value to be consigned to areas of noncompliance could be 1 percent for maximum protection to 10 percent for a low level of protection, with values from 1-10 selected for intermediate protection. More than 10 percent could be chosen where economics or other considerations warrant, or restricted all to less than 1 percent for unique biological environments.

LOCATION AND SIZE

The position of areas of noncompliance relative to each other is important. Where they contain different components (such as heat and copper) or they are adjacent or overlapping, special consideration is required. Overlapping areas are acceptable if there is no significant additive effect and the toxicity limits given previously are met. In this way, less area is used for a given number of dischargers, although regulatory problems may be more difficult. Previous methods for establishing mixing zones have resulted in fixed zone sizes (such as an area equivalent to a circle with a radius of 1,000 feet). With the present concept, the size is fixed by its impact on the biological value, rather than by some predetermined physical limit.

While recognizing that size is related to biological value, certain notions can be expressed. For physical reasons, the size of the area of noncompliance may need to be greater for large discharges than for small ones. The permissible size depends in part on the size of the water body segment, the larger the segment, the larger the mixing zone may be without exceeding a given portion of the total segment. The acceptable size depends also on the number of areas of noncompliance in a water body segment. The greater the number, the smaller each must be in order to keep the area devoted to these areas sufficiently small. In this connection, future growth of industry and population resulting in additional discharges must be considered. In addition, there are some segments of the Great Lakes that have been excessively degraded

as a result of man's activity and these areas will require rehabilitation. Once judgements have been made on biological value and level of protection, the administrative process of allocating areas of noncompliance takes place.

SUMMARY

Those of us who support the use of environmental maps as the first step in the development of a relative environmental or biological value system for the allocation of areas of noncompliance realize the difficulties and necessary subjective nature of some aspects of this system. We believe that it is not the best solution to the control of point source discharges but it is an attempt to attack the problem of areas of noncompliance in a scientific manner rather than in the current random, haphazard method. It has seldom proved successful to demand that all pollution be kept from entering the Great Lakes. It is now time for a reasonable, conservative approach toward determining the acceptable limits of use of these waters. All of our efforts to develop scientifically-defensible water quality objectives for Great Lakes aquatic life will be meaningless unless we are able to develop a procedure for determining where these objectives are to be applied.